International Journal of Medical and Health Research
ISSN: 2454-9142
Received: 01-10-2020; Accepted: 16-10-2020; Published: 02-11-2020
www.medicalsciencejournal.com
Volume 6; Issue 11; 2020; Page No. 01-04

The effect of Er: YAG laser surface treatment to acrylic resin denture base on the peel bond strength of silicone-based resilient liner

Al-Shakaki Hala[1], Al-Essa Hussein[2]
[1] PhD. Student, Department of Removable Prosthodontics. Faculty of Dentistry. Hama University, Syria
[2] Assistant Professor, Department of Conservative Dentistry & Removable Prosthodontics, Faculty of Dentistry, Hama University, Dean of the Faculty of Dentistry in Al-Wataniya Private University, Syria

Abstract
Statement of problem: Adhesive failure between the liner and the denture base creates an environment for potential bacterial growth and accelerated breakdown of the soft liner resulting in a deteriorating prosthesis.
Purpose This study evaluated the effect of lased preparation on the interracial bonding of polymethyl methacrylate and auto polymerization silicon-based soft lining material.
Materials and Methods: Ten complete mandibular dentures were selected to be relining, half of the denture was laser Er: YAG treated and the other half untreated (control). Then the silicone-based soft liner material (Ufi-Gel P) was applied. The peel bond strength test was examined by Instron Universal Testing Machine at crosshead speed of 30mm/min. T-student test was used to analyze the data (α=0.05).
Results: Altering the polymethyl methacrylate surface by laser Er:YAG significantly increased the peel strengths for the silicone lining material with the denture base in compere with the controls($P<0.05$).
Conclusions: Results of this study imply that mechanical surface preparation (laser irradiation) of denture bases before application of a resilient liner shows higher peel bond strength.

Keywords: PMMA. Soft denture liner. Er: YAG laser. Peel bond strength

Introduction

Resilient lining materials are used on dental prostheses to aid in the distribution of functional loads to the denture bearing areas, to avoid localized stress concentrations, and to improve retention by engaging undercuts [1, 2]. Resilient liners have been shown to increase a patient's level of comfort during mastication [3, 4]. Therefore, laboratory processed materials are used as long-term denture liners in the management of frail and chronically irritated tissues [2, 5]. Maxillofacial patients recovering from head and neck cancer surgeries may also benefit from the use of resilient materials in the restoration of surgical defects [6].

Numerous materials have been used as resilient liners since the introduction of velum rubber [7, 8]. Many have been used with varying levels of success, but limitations exist in the areas of cleansability, hardness, volumetric change due to water absorption, and abrasion resistance [9, 14]. One problem is the adhesive failure that occurs between the liner and the denture base [15]. The importance of the bond strength was recognized when Wright [8] concluded that the most common reason for failure of a soft-lined denture was the failure of "adhesion" between the liner and denture base.

Craig and Gibbons [9] advocated a roughened surface to improve the adhesive bond. They reported that adhesive values obtained with the roughened surface were approximately double those of the smooth surface.

Researchers have attempted to identify many methods to improve the polymethyl methacrylate (PMMA)/ resilient liner bond [16, 17]. Recently, lasers have been shown to provide a relatively safe and easy means of altering the surface of materials. Although lasers have not been used to roughen PMMA surfaces before application of a resilient liner, they have been used to etch metals before application of porcelain [18].

Materials and Methods

The resilient denture lining materials involved in this study was auto polymerization silicon-based soft lining material [Ufi-Gel P Voco, Germany), and the denture base material was heat-curing acrylic resin.

Ten patients were randomly selected from among the patients attending the prosthetic department clinics. (8) Of them were males and (2) females.

The indications for relining of these patient's dentures can be summed up with:

1. Very absorbent ridge.
2. The presence of undercut areas.

Removing from the interior surface of the mandibular denture a thickness of 1-2 mm was made according to the case. Then we rotate the resulting edges and wash the denture well. We draw a line in the middle of the lower denture so that it divides the denture into almost two equal parts, and then half of the interior surface of the denture was treated with laser Er: YAG (KaVo KEY Laser 3 1243/Germany) at a frequency 10Hz and an energy level 300 mJ, and the other half was left untreated (control). (Figure 1-2)

The surface of the interior lower denture was cleaned and wiped with a cotton tip wet with alcohol and allowed to dry, and then the adhesive was applied using the brush cover supplied with the adhesive and was wiped over the entire interior surface to which the soft lining material will be applied and left for a minute. After applying the adhesive, the soft lining material was prepared by mixing two equal lengths of the base (red) and the accelerator (blue) for 30 seconds to obtain a uniform consistency and then it was applied to the test surface of the denture. And then it was entered inside the patient's mouth and the edges were adjusted by performing the appropriate movements, and then asking the patient to close his mouth in the central relation position. The soft lined material was left for 5 minutes until hardening. After hardening, the denture was removed from the patient's mouth.

The extra material was removed using a sharp scalpel after 10 minutes since application of the material.

The soft lining material was polished using a Glaze, where a drop of the base was mixed with a drop of accelerator and brushed on the all acrylic edges and left for 10 minutes to dry at room temperature, then the denture is returned back in the patient's mouth.

After one week of placing the denture in the patient's mouth, the peel strength was tested by using the universal testing machine (Fig. 3). The dentures were tested at a crosshead speed of 30 mm/min until the liner material was separated from the acrylic surface in the treated side and then in the untreated side.

After complete failure occurs on both sides, surfaces of bond failure were examined visually and probed (on both sides) using a fine probe for determining the type of failure (cohesive or adhesive). (Fig. 4)

Fig 1: Treatment of the interior side of the mandibular denture with laser irradiation

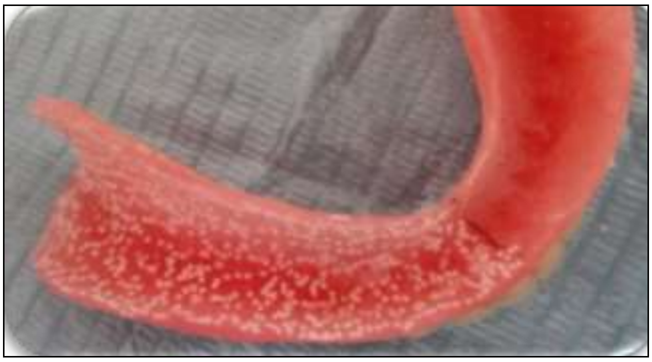

Fig 2: Appling laser irradiation on the bonding surface of the denture

Fig 3: Peel bond strength test of the denture by using the universal testing machine

Fig 4: Using a fine probe for determining the type of failure (cohesive or adhesive).

Results

The mean peel bond strength values, standard deviations, and the type of bond failure are presented in Table 1. The highest mean force value is observed in group L while the lowest peel bond strength observed in group N with statistically significant differences ($p<0.05$).

We also note that the mean cohesive failure in the laser group is higher than the control group. While the mean adhesive failure in the laser group is lower than the control group.

Table 1: Mean peel bond strengths, standard deviation and the type of bond failure.

Surface treatment	Mean peel bond strength (N)	Standard deviation	Mean Type of failure (% Coh)	Mean Type of failure (% Adh)
N	5.26	0.46	0	100
Laser	11.20	0.43	1.70	98.30

Discussion

Resilient denture liners have been a valuable asset in clinical prosthetics because of their viscoelastic properties, which reduce mucosal discomfort when there is a reduced tolerance to loads applied by dentures [19].

Clinically, the ability of denture lining materials to resist debonding and internal fracture under masticatory stresses is extremely important. To achieve better bonding results, several experimental procedures have been conducted to test variables such as type of soft liner used, type of acrylic resin, polymerization stage of acrylic resin, use of adhesive, type of bonding test, and water storage of specimens. This study focused on the surface treatment of denture base [20].

Silicone-based resilient lining material is more commonly used, as it is more widely preferred by dentists due to its several advantages. Because of that we used this type of soft liner (Ufi Gel P) to study it in our research.

However, there have not been enough published articles investigating the effect of laser surface treatments on peel bond strength of soft lining material to acrylic denture resin.

The type of bond test used is closely related to the bond strength measurement, having a characteristic load application and pattern in which the load is distributed to the bond interface. In assessing the bond strength of soft denture liners, different results would be obtained if different test methods were used. Wright has reported that the adhesion of all soft liners is best characterized by a peel test. The peel test process simulates a reline procedure more accurately, with an even distribution of force over the bonding area [20].

Because lasers are becoming more prevalent in the dental profession, they have been used to alter the surface of the PMMA with the intention of providing increased surface area and mechanical locks. Theoretically, both manipulations (increased surface area and mechanical locks) should benefit the bond site and result in stronger bonds [21].

The results of the present study showed that Er: YAG laser irradiation increased the bond strength of the acrylic denture base resin to the silicone relining material. Heat-cured acrylic resin with laser pretreatment at 300 mJ, 10 Hz showed significantly increased bond strengths to the soft liner Ufi-Gel P compared to the control groups.

These results are consistent with a study of Korkmaz *et al.* [22] which concluded that denture base liner tested showed increased peel strength after laser treatment of denture base resin compared to the untreated.

This can be explained by the high energy of the Er: YAG laser. The energy produced by the Er: YAG laser might be in interaction with the water droplets at the tissue surface in order to create water molecule excitation causing the water droplet micro expansion and propulsion [23, 24]. An increased surface area may be formed by this expansion which causes the surrounding material to ablate [23, 24, 25]. Increased surface and mechanical interlocking may be related with the bond strength. It is known that the surface roughness may be increased and the contact angle between PMMA and their control liquids may be decreased, which may help the penetration of the soft liner into the irregularities on the acrylic surface, by the laser application [26].

While, Jacobsen *et al.* [27] examined the effect of lasing and sandblasting, but it came out that changing the PMMA surface by lasing with a CO2 laser reduced the peel strength values in comparison with the untreated surface test samples. These results disagree with our results.

These controversial results may be explained by the type of lasers, differences in the applied energy, different structures of denture base resin, and different testing environment. One possible explanation for the different effects between lasers might be the different absorption capacity of resin materials.

Conclusions

Within the limitations of this study, it can be concluded that heat-cured acrylic resin, PMMA, may benefit from Er: YAG laser treatment at 300mJ-20 Hz irradiation.

As the application of laser treatment increases the peel strength between the denture base resin and the soft liner material.

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